Department of Information Engineering (DEI) – University of Padova

INVITATION FOR COMPETITIVE BID



Spectral Analysis for Kinetic Estimation

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Introduction

Positron Emission Tomography (PET) is a nuclear imaging technique which allows the *in vivo* estimation of important physiological parameters, such as blood flow, glucose metabolism and neuroreceptor binding. In PET, radioactive tracers which decay by positron emission are injected into the patient/animal being studied. The subject is then positioned into a scanner where special scintillator crystals are employed to detect the photon emissions. The final outcome of these measurements is the distribution of the tracer over time in the area of interest (e.g. the brain). A graphical representation of a typical PET exam is reported in Figure 1.

Unfortunately the outcomes of a PET exam are not directly accessible. In order to derive clinical and physiological information about the patient status PET data need to be elaborated. Different quantification methods can be applied, depending on the user interests and on the characteristics of the PET data (Figure 2).

One of these methods is represented by Spectral Analysis (SA). SA is a very powerful and flexible PET quantification tool but its utilization in the nuclear medicine community has been limited especially by the lack of an user-friendly application support. Hence SA utilization has been restricted to those scientists with enough computer knowledge to be able to individually implement SA algorithms.



Figure 1. Graphical representation of a PET exam. 1) Administration of the radioactive tracer to the patience; 2) Scanner registration of the tracer emissions; 3) Data processing; 4) PET image reconstruction.



Figure 2. Example of PET image quantification. The outcome of a PET exam (typically a 4-dimensions data matrix) is processed using a quantification method. The analysis can be carried out at region of level, when only single signals are analyzed, or at voxel level, when the entire image is processed as a whole.

The Project

Objectives of the bid

The invitation to bid (hereinafter referred to as ITB) is designed to solicit proposals from qualified vendors who will be responsible **to develop a software for the elaboration of PET data through the spectral analysis methods**. The main aim is to offer to the international scientific community a complete tool which realizes all the characteristics of SA. This tool has to be as much user friendly as possible in order to allow its utilization by people with limited computer knowledge (e.g.: doctors, biologists, chemists, clinicians,...) but with high interest in SA.

Project Support

This ITB is supported by the Bioengineering group of the Department of Information Engineering (University of Padova) and by the PET methodology group of Hammersmith Hospital (Imperial Collage of London).

The purchaser group (hereinafter referred to as COM) reserves the right to accept or reject any or all proposals received as a result of the ITB in whole or in part, to negotiate with all qualified bidder, and/or to cancel in whole or in part the ITB if in the best interest of the COM.

Mandatory Requirements

Mandatory requirements are explicitly indicated in the ITB, section Software. All the mandatory requirements must be fully satisfied.

Optional Requirements

Optional requirements are explicitly indicated in the ITB, *section Software*. The realization of the optional requirements does not undermine the eligibility of the proposals but it will be considered as evaluation criteria.

Change of requirements

Changes in the mandatory requirements are allowed only in the directions of clear improvements of the COM requests. The COM reserves the right to change the mandatory requirements during all the bid process, i.e. before the proposal submission as well as the during the realization phase.

Documentation

The proposer must provide an operating manual and all the technical documentation necessary for the software utilization. The use of English language is required. All such documents must be included in the delivery of the product.

Warranty and Maintenance

The proposer must be capable of guarantying the correctness of its application. The proposer shall host development, test, and quality assurance environments during and through the project life cycle. This will include system application modification testing as well as conversion data testing.

The proposer must be capable of providing full support for its application. This will include the corrections for the not conformities of the software coming out from the test phase.

The test proceeding will be indicated by the proposer and it will be considered as criteria for the proposal evaluation. The COM reserves the right to reject the test proceeding indicated by the proposer and suggests alternative testing solutions.

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Expandability

The proposer must be capable of ensuring the future expandability of its application. The characteristics of expandability of the software will be considered as criteria for the proposal evaluation.

Discussion

The COM reserves the right to seek clarifications from bidder so as to assure a full understanding of the proposed activities and processes. Eligible bidder will be accorded fair and equal treatment with respect to any opportunity for discussions and revisions concerning their proposals.

Notification

During the bid period, all communication between the COM and a proposer shall be between a proposer's representative and the COM contacts.

COM contacts

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Errors and omissions

The proposer shall not take advantage of any errors and/or omissions in this ITB. The proposer must promptly notify the COM of any errors and/or omissions that are discovered.

Terms and Conditions

Proposals shall conform to all instructions, conditions, and requirements included in the ITB. Prospective bidder are expected to carefully examine all documentation, schedules and requirements stipulated in this ITB, and respond to each requirement in the format prescribed. The proposals will first be examined to determine if all mandatory requirements listed below have been addressed to warrant further evaluation. Proposals not meeting mandatory requirements will be excluded from further evaluation.

This ITB is written conforming the laws for the management of public procurements. The COM referred to that laws for all the missing details concerning the ITB.

No commercial Purposes

The aim of the ITB is NOT to create a software with commercial purposes. Instead proposals will represent prototypal examples which will demonstrate the feasibility of a PET quantification software based on spectral analysis algorithms.

SOFTWARE

General Aspects

All the functionalities and the algorithms related to the elaboration of biomedical data will be provided by the COM.

The proposer is supposed to design and develop an application which allows the cooperation of all the functional blocks below described, according to good software engineering practices.

Mandatory Requirements:

- The software has to be created as a stand-alone application;
- The language of the software documents and online data in the application MUST be English;
- The software has to work on Windows, Linux and Mac platforms (both 32-bit and 64bit);
- The software must provide a Graphical User Interface (GUI) as a front-end to the application;
- The GUI has to follow an intuitive scheme to be used by expert and not expert ICT users;
- The software has to realize an echo window where suggestions about software utilization and notifications about software status are reported real-time.

Structure of the application

Mandatory Requirements:

- The software has to consist in 3 different functional blocks (Table 1);
- Each block has to work independently from the others;
- The output of a block could be used as input for another block;

BLOCK	AIMS of the BLOCK
Pre-Processing	Analysis and elaboration of the raw outcomes of PET exams
SA quantification	Application of Spectral Analysis quantification methods to the outcomes of PET exams (which can eventually be pre-processed by the Pre-processing block)
Analysis of Results	Visualization of the results obtained with the SA quantification block

Pre-Processing Block

The aim of this block is to operate an elaboration of the raw outcomes from a PET exam preliminarily to the quantification. With this block three different types of data have to be managed:

- 1) Arterial Input Function data
- 2) PET Data at region level
- 3) PET Data at voxel level

With the term Arterial Input Functions (AIFs) we refer to the blood signals that are measured during the PET exams. For this particular kind of signals the pre-processing block has to visualize the data, fit the time course of the curves through specific models, pre-loaded in the software and perform the decay corrections (if specified by the users).

With the term PET data at region level we refer to the activity of the tracer measured in specific volume of interest. For this particular kind of data the pre-processing block has to visualize the data and perform the decay corrections (if specified by the users). An example of PET data analysis at region level is reported in Figure 3, where the AIF (input function) and the time course of a region curve are represented.

With the term PET data at voxel level we refer to the activity of the tracer measured in each voxels of a specific volume of interest. For this particular kind of data the pre-processing block has to visualize in an appropriate way 4-D images, perform the sum of 4D images over the time direction and perform the decay corrections (if specified by the users). An example of PET data analysis at voxel level is reported in Figure 4, where a summed PET image is shown in the three planes.



Figure 3. Example of analysis at region level



Figure 4. Example of analysis at voxel level

SA quantification Block

The Spectral Analysis quantification block is the part of the software dedicated to the quantification of PET data. The quantification block has to implement 3 different types of spectral analysis methods: Standard, Rank Shaping and Iterative Filter (source code will be provided by the COM). Each method has to be available for the quantification of both region and voxel data.

Analysis of Results Block

The aim of this block is to visualize the results of the SA quantification block. The type of results is related to the type of analyzed data. Depending on the level of analysis (region or voxel) results have to be adequately loaded, visualized and saved.

Algorithms

All the functionalities and the algorithms related to the elaboration of biomedical data will be provided by the COM as Matlab files with a detailed description of inputs and outputs. The proposer can choose the programming language and hence the appropriate builder to export the Matlab source (examples: Matlab Builder JA, Matlab Builder C++).

Project Degree of Freedom

GUI

One critical point of the software regards the necessity to allow its utilization by people with limited computer knowledge. Hence the use of the software has to be as user-friendly as possible. In order to achieve this result the bidder are free to design the best solutions they want, with particular interest to the GUI of the software. Innovative solutions will be considered as criteria for the proposal evaluation.

Innovative solutions for the visualization and management of images and data plot

Moreover it will be very relevant for the proposal evaluation the way in which images and data plot will be treated by the software in term of *quality* of visualization and easiness of interaction with the software users.

Reference Application

To help the proposer form a better idea about the type of software requested by the ITB, the COM recommend looking at CARIMAS 2.0 at the following web address: <u>http://www.turkupetcentre.fi/index.php?option=com_content&view=article&id=230&Itemid=37</u> <u>&lang=en</u>. CARIMAS 2.0 must be considered only as an example of a PET quantification software and not a goal to be replicated.

Alternative solutions will be considered with particular interest, provided that they fulfill all the mandatory requirements of the project.